ON THE STUDY OF BIOLOGY.[1]

BY PROF. T. H. HUXLEY.

THE sense in which "natural history" was used at the time I am now speaking of has, to a certain extent, endured to the present day. There are now in existence, in some of our northern universities, chairs of civil and natural history, in which the term natural history is used to indicate exactly what Hobbes and Bacon meant by that term. There are others in which the unhappy incumbent of the chair of natural history is, or was, still supposed to cover the whole ground of geology and mineralogy, zoölogy, perhaps even botany, in his lectures. But as science made the marvelous progress which it did make at the end of the last and the beginning of the present century, thinking men began to discern that under this title of natural history there were included very heterogeneous constituents, — that, for example, geology and mineralogy were, in many respects, very different from botany and zoölogy; that a man might obtain an extensive knowledge of the structure and functions of plants and animals without having need to enter upon the study of geology and mineralogy, and *vice versa;* and further, as knowledge advanced, it became clear that there was a great analogy, a very close alliance, between those two sciences of botany and zoology which deal with living beings, while they are much more widely separated from all other studies. It is due to Buffon to remark that he clearly recognized this great fact. He says: "Ces deux genres d'êtres organisés (les animaux et les végétaux) ont beaucoup plus de propriétés communes que de différences réelles." Therefore it is not wonderful that at the beginning of the present century, and oddly enough in two different countries, and, so far as I know, without any intercommunication between the respective writers, two famous men clearly conceived the notion of uniting the whole of the sciences which deal with living matter into one whole, and of dealing with them as one discipline. In fact, I may say there were three men to whom this idea occurred contemporaneously, although there were but two who carried it into effect, and only one who worked it out completely. The persons to whom I refer were the eminent physiologist Bichat,[2] the great naturalist Lamarck, in France, and a distinguished

[1] Extracts from a lecture by Professor Huxley, delivered at the South Kensington Museum, on Saturday, December 16, 1876.

[2] See the distinction between the "sciences physiques" and the "sciences physiologiques" in the Anatomie Générale, 1801.

German, Treviranus. Bichat assumed the existence of a special group of "physiological" sciences. Lamarck, in a work published in 1801,[1] for the first time made use of the name "biologie," from the two Greek words which signify a *discourse upon life and living things.* About the same time it occurred to Treviranus that all those sciences which deal with living matter are essentially and fundamentally one, and ought to be treated as a whole, and in the year 1802 he published the first volume of what he also called Biologie. Treviranus's great merit consists in this, that he worked out his idea, and that he published the very remarkable book to which I refer, which consists of six volumes, and which occupied him for twenty years, — from 1802 to 1822.

That is the origin of the term "biology," and that is how it has come about that all clear thinkers and lovers of consistent nomenclature have substituted for the old confusing name of natural history, which has conveyed so many meanings, the term biology, to denote the whole of the sciences which deal with living things, whether they be animals or whether they be plants.

Having now defined the meaning of the word biology, and having indicated the general scope of biological science, I turn to my second question, which is, Why should we study biology? Possibly the time may come when that will seem a very odd question. That we, living creatures, should not feel a certain amount of interest in what it is that constitutes our life will eventually, under altered ideas of the fittest objects of human inquiry, seem to be a singular phenomenon; but at present, judging by the practice of teachers and educators, this would seem to be a matter that does not concern us at all. I propose to put before you a few considerations which I dare say many of you will be familiar with already, but which will suffice to show — not fully, because to demonstrate this point fully would take a great many lectures — that there are some very good and substantial reasons why it may be advisable that we should know something about this branch of human learning. I myself entirely agree with another sentiment of the philosopher of Malmesbury, that "the scope of all speculation is the performance of some action or thing to be done," and I have not any very great respect for or interest in mere knowing as such. I judge of the value of human pursuits by their bearing upon human interests, — in other

[1] Hydrogéologie, an. x., 1801.

words, by their utility; but I should like that we should quite clearly understand what it is that we mean by this word "utility." Now, in an Englishman's mouth, it generally means that by which we get pudding or praise, or both. I have no doubt that is one meaning of the word utility, but it by no means includes all I mean by utility. I think that knowledge of every kind is useful in proportion as it tends to give people right ideas, which are essential to the foundation of right practice, and to remove wrong ideas, which are the no less essential foundations and fertile mothers of every description of error in practice. And, upon the whole, inasmuch as this world is, after all, whatever practical people may say, absolutely governed by ideas, and very often by the wildest and most hypothetical ideas, it is a matter of the very greatest importance that our theories of things, and even of things that seem a long way apart from our daily lives, should be as far as possible true, and as far as possible removed from error. It is not only in the coarser practical sense of the word utility, but in this higher and broader sense, that I measure the value of the study of biology by its utility, and I shall try to point out to you that you will feel the need of some knowledge of biology at a great many turns of this present nineteenth-century life of ours. For example, most of us lay great and very just stress upon the conception which is entertained of the position of man in this universe, and his relation to the rest of nature. We have almost all of us been told, and most of us hold by the tradition, that man occupies an isolated and peculiar position in nature; that though he is in the world he is not of the world; that his relations to things about him are of a remote character, that his origin is recent, his duration likely to be short, and that he is the great central figure round which other things in this world revolve. But this is not what the biologists tell us. At the present moment you will be kind enough to separate me from them, because it is in no way essential to my argument just now that I should advocate their views. Don't suppose that I am saying this for the purpose of escaping the responsibility of their beliefs, because at other times and in other places I do not think that point has been left doubtful; but I want clearly to point out to you that for my present argument they may all be wrong; nevertheless, my argument will hold good. The biologists tell us that all this is an entire mistake. They turn to the physical organization of man. They examine his whole structure, his bony frame, and all that clothes it. They resolve him into the finest particles

into which the microscope will enable them to break him up. They consider the performance of his various functions and activities, and they look at the manner in which he occurs on the surface of the world. Then they turn to other animals, and, taking the first handy domestic animal, — say a dog, — they profess to be able to demonstrate that the analysis of the dog leads them in gross to precisely the same results as the analysis of the man; that they find almost identically the same bones, having the same relations; that they can name the muscles of the dog by the names of the muscles of the man, and the nerves of the dog by those of the nerves of the man, and that such structures and organs of sense as we find in the man, such also we find in the dog; they analyze the brain and spinal cord, and find the nomenclature which does for the one answer for the other. They carry their microscopic inquiries in the case of the dog as far as they can, and they find that his body is resolvable into the same elements as those of the man. Moreover, they trace back the dog's and the man's development, and they find that at a certain stage of their existence the two creatures are not distinguishable the one from the other; they find that the dog and his kind have a certain distribution over the surface of the world comparable in its way to the distribution of the human species. What is true of the dog they tell us is true of all the higher animals; and they find that for the whole of these creatures they can lay down a common plan, and regard the man and the dog, the horse and the ox, as minor modifications of one great fundamental unity. Moreover, the investigations of the last three quarters of a century have proved, they tell us, that similar inquiries carried out through all the different kinds of animals which are met with in nature will lead us, not in one straight series, but by many roads, step by step, gradation by gradation, from man at the summit to specks of animated jelly at the bottom of the series; so that the idea of Leibnitz and of Bonnet, that animals form a great scale of being in which there is a series of gradations from the most complicated form to the lowest and simplest, — that idea, though not exactly in the form in which it was propounded by those philosophers, turns out to be substantially correct. More than this, when biologists pursue their investigations into the vegetable world, they find that they can in the same way follow out the structure of the plant from the most gigantic and complicated trees through a similar series of gradations until they arrive at similar specks of animated jelly, which they are puzzled to distinguish from those which they reached by the animal road.

Thus they have arrived at the conclusion that a fundamental uniformity of structure pervades the animal and vegetable worlds, and that plants and animals differ from one another simply as modifications of the same great general plan.

Again, they tell us the same story in regard to the study of function. They admit the large and important interval which, at the present time, separates the manifestations of the mental faculties observable in the higher forms of mankind, and even in the lower forms, such as we know them, mentally from those exhibited by other animals; but, at the same time, they tell us that the foundations or rudiments of almost all the faculties of man are to be met with in the lower animals; that there is a unity of mental faculty as well as of bodily structure, and that here also the difference is a difference of degree and not of kind. I said "almost all" for a reason. Among the many distinctions which have been drawn between the lower creatures and ourselves, there is one which is hardly ever insisted on,[1] but which may be fitly spoken of in a place so largely devoted to art as that in which we are assembled. It is this, that while among various kinds of animals it is possible to discover traces of all the other faculties of man, especially the faculty of mimicry, yet that particular form of mimicry which shows itself in the imitation of form, either by modeling or by drawing, is not to be met with. As far as I know, there is no sculpture or modeling, and decidedly no painting or drawing of animal origin. I mention the fact in order that such comfort may be derived therefrom as artists may feel inclined to take.

If what the biologists tell us is true, it will be needful for us to get rid of our erroneous conceptions of man and of his place in nature, and substitute for them right ones.

Granted that biology is something worth studying, what is the best way of studying it? Here I must point out that, since biology is a physical science, the method of studying it must needs be analogous to that which is followed in the other physical sciences. It has now long been recognized that if a man wishes to be a chemist it is not only necessary that he should read chemical books and attend chemical lectures, but that he should actually himself perform the fundamental experiments in the laboratory, and know exactly what the words which he finds in his books and hears from his teachers mean. If he does not do that, he may read till the crack of doom, but he will never know

[1] I think that Professor Allman was the first to draw attention to it.

much about chemistry. That is what every chemist will tell you, and the physicist will do the same for his branch of science. The great changes and improvements in physical and chemical scientific education which have taken place of late have all resulted from the combination of practical teaching with the reading of books and with the hearing of lectures. The same thing is true in biology. Nobody will ever know anything about biology, except in a dilettant "paper-philosopher" way, who contents himself with reading books on botany, zoölogy, and the like; and the reason of this is simple and easy to understand. It is, that all language is merely symbolical of the things of which it treats; the more complicated the things, the more bare is the symbol, and the more its verbal definition requires to be supplemented by the information derived directly from the handling, and the seeing, and the touching of the thing symbolized: that is really what is at the bottom of the whole matter. It is plain common sense, as all truth in the long run is, only common sense clarified. If you want a man to be a tea-merchant, you don't tell him to read books about China or about tea, but you put him into a tea-merchant's office, where he has the handling, the smelling, and the tasting of tea. Without the sort of knowledge which can be gained only in this practical way, his exploits as a tea-merchant will soon come to a bankrupt termination. The paper-philosophers are under the delusion that physical science can be mastered as literary accomplishments are acquired, but unfortunately it is not so. You may read any quantity of books, and you may be almost as ignorant as you were at starting if you don't have, at the back of your minds, the change for words in definite images which can only be acquired through the operation of your observing faculties on the phenomena of nature.

It may be said: "That is all very well, but you told us just now that there are probably something like a quarter of a million different kinds of living and extinct animals and plants, and a human life could not suffice for the examination of one fiftieth part of all this." That is true, but then comes the great convenience of the way things are arranged; which is, that, although there are these immense numbers of different kinds of living things in existence, yet they are built up, after all, upon marvelously few plans.

There are, I suppose, about 100,000 species of insects, if not more, and yet anybody who knows one insect — if a properly

chosen one — will be able to have a very fair conception of the structure of the whole. I do not mean to say he will know that structure thoroughly, or as well as it is desirable he should know it, but he will have enough real knowledge to enable him to understand what he reads, to have genuine images in his mind of those structures which become so variously modified in all the forms of insects he has not seen. In fact, there are such things as types of form among animals and vegetables, and for the purpose of getting a definite knowledge of what constitutes the leading modifications of animal and plant life it is not needful to examine more than a comparatively small number of animals and plants.

Let me tell you what we do in the biological laboratory in the building adjacent to this. There I lecture to a class of students daily for about four and a half months, and my class have, of course, their text-books; but the essential part of the whole teaching, and that which I regard as really the most important part of it, is a laboratory for practical work, which is simply a room with all the materials arranged for ordinary dissection. We have tables properly arranged in regard to light, microscopes, and dissecting instruments, and we work through the structure of a certain number of animals and plants. As, for example, among the plants we take a yeast plant, a *Protococcus*, a common mould, a *Chara*, a fern, and some flowering plant; among the animals, we examine such things as an amœba, a *Vorticella*, and a fresh-water polyp. We dissect a star-fish, an earth-worm, a snail, a squid, and a fresh-water mussel. We examine a lobster and a craw-fish and a black beetle. We go on to a common skate, a cod-fish, a frog, a tortoise, a pigeon, and a rabbit, and that takes us about all the time we have to give. The purpose of this course is not to make skilled dissectors, but to give every student a clear and definite conception, by means of sense-images, of the characteristic structure of each of the leading modifications of the animal kingdom; and that is perfectly possible, by going no further than the length of that list of forms which I have enumerated. If a man knows the structure of the animals I have mentioned, he has a clear and exact, however limited, apprehension of the essential features of the organization of all those great divisions of the animal and vegetable kingdoms to which the forms I have mentioned severally belong. And it then becomes possible for him to read with profit, because, every time he meets with the name of a structure, he has a definite image in his mind of what the

name means in the particular creature he is reading about, and therefore the reading is not mere reading. It is not mere repetition of words; but every term employed in the description, we will say, of a horse or of an elephant, will call up the image of the things he had seen in the rabbit, and he is able to form a distinct conception of that which he has not seen as a modification of that which he has seen.

I find this system to yield excellent results, and I have no hesitation whatever in saying that any one who has gone through such a course attentively is in a better position to form a conception of the great truths of biology, especially of morphology (which is what we chiefly deal with), than if he had merely read all the books on that topic put together.

The connection of this discourse with the Loan Collection of Scientific Apparatus arises out of the exhibition in that collection of aids to our laboratory work. Such of you as have visited that very interesting collection may have noticed a series of diagrams and of preparations illustrating the structure of a frog. Those diagrams and preparations have been made for the use of the students in the biological laboratory. Similar diagrams and preparations, illustrating the structure of all the other forms of life we examine, are either made or in course of preparation. Thus the student has before him, first, a picture of the structure he ought to see; secondly, the structure itself worked out; and if, with these aids, and such needful explanations and practical hints as a demonstrator can supply, he cannot make out the facts for himself in the materials supplied to him, he had better take to some other pursuit than that of biological science.

I should have been glad to have said a few words about the use of museums in the study of biology, but I see that my time is becoming short, and I have yet another question to answer. Nevertheless, I must, at the risk of wearying you, say a word or two upon that important subject of museums. Without doubt, there are no helps to the study of biology, or rather to some branches of it, which are or may be more important than natural-history museums; but, in order to take this place in regard to biology, they must be museums of the future. The museums of the present do not do by any means so much for us as they might do. I do not wish to particularize, but I dare say many of you seeking knowledge, or in the laudable desire to employ a holiday usefully, have visited some great natural-history museum. You have walked through a quarter of a mile of animals well

stuffed, with their long names written out underneath them; and, unless your experience is very different from that of most people, the upshot of it all is that you leave that splendid pile with sore feet, a bad headache, and a general idea that the animal kingdom is a mighty maze without a plan. I do not think that a museum which brings about this result has done all that may reasonably be expected of such an institution. What is needed in a collection of natural history is, that it should be made as accessible and as useful as possible on the one hand to the general public, and on the other to scientific workers. That need is not met by constructing a sort of happy hunting ground of miles of glass cases, and, under the pretense of exhibiting everything, putting the maximum amount of obstacles in the way of those who wish properly to see anything.

What the public want is easy and unhindered access to such a collection as they can understand and appreciate; and what the men of science want is similar access to the materials of science. To this end the vast mass of objects of natural history should be divided into two parts, — one open to the public, the other to men of science, every day, and all day long. The former division should exemplify all the more important and interesting forms of life. Explanatory tablets should be attached to them, and catalogues, containing clearly written expositions of the general significance of the objects exhibited, should be provided. The latter division should contain, packed into a comparatively small space, the objects of purely scientific interest. For example, we will say I am an ornithologist. I go to see a collection of birds. It is a positive nuisance to have them stuffed. It is not only sheer waste, but I have to reckon with the ideas of the bird stuffer, while if I have the skin and nobody has interfered with it, I can form my own judgment as to what the bird was like. For ornithological purposes, what is needed is not glass cases full of stuffed birds on perches, but convenient drawers, into each of which a great quantity of skins will go. They occupy no great space, and do not require any expenditure beyond their original cost. But, for the purpose of the public, who want to learn, indeed, but do not seek for minute and technical knowledge, the case is different. What one of the general public, walking into a collection of birds, desires to see, is not all the birds that can be got together; he does not want to compare a hundred species of the sparrow tribe side by side; but he wishes to know what a bird is, and what are the great modifications of bird structure,

and to be able to get at that knowledge easily. What will best serve his purpose is a comparatively small number of birds, carefully selected, and artistically as well as accurately set up, with their different ages, their nests, their young, their eggs, and their skeletons side by side, and, in accordance with the admirable plan which is pursued in this museum, a tablet, telling the spectator, in legible characters, what they are and what they mean. For the instruction and recreation of the public, such a typical collection would be of far greater value than any many-acred imitation of Noah's ark.

Lastly comes the question as to when biological study may best be pursued. I do not see any valid reason why it should not be made, to a certain extent, a part of ordinary school training. I have long advocated this view, and I am perfectly certain that it can be carried out with ease, and not only with ease, but with very considerable profit to those who are taught; but then such instruction must be adapted to the minds and needs of the scholars. They used to have a very odd way of teaching the classical languages when I was a boy. The first task set you was to learn the rules of the Latin grammar in the Latin language, — that being the language you were going to learn. I thought then that this was an odd way of learning a language, but did not venture to rebel against the judgment of my superiors. Now, perhaps, I am not so modest as I was then, and I allow myself to think it was a very absurd fashion. But it would be no less absurd if we were to set about teaching biology by putting into the hands of boys a series of definitions of the classes and orders of the animal kingdom, and making them repeat them by heart. That is a very favorite method of teaching, so that I sometimes fancy the spirit of the old classical system has entered into the new scientific system, in which case I would much rather that any pretense at scientific teaching were abolished altogether. What really has to be done is to get into the young mind some notion of what animal and vegetable life is. You have to consider in this matter practical convenience as well as other things. There are difficulties in the way of a lot of boys making messes with slugs and snails; it might not work in practice. But there is a very convenient and handy animal which everybody has at hand, and that is himself; and it is a very easy and simple matter to obtain common plants. Hence, the broader facts of anatomy and physiology can be taught to young people in a very real fashion by dealing with

the broad facts of human structure, such as hearts, lungs, and livers. Such viscera as they cannot very well examine in themselves may be obtained from the nearest butcher's shop. In respect to teaching them something about the biology of plants, there is no practical difficulty, because almost any of the common plants will do, and plants do not make a mess, — at least they do not make an unpleasant mess; so that, in my judgment, the best form of biology for teaching to very young people is elementary human physiology on the one hand, and the elements of botany on the other; beyond that I do not think it will be feasible to advance for some time to come. But then I see no reason why in secondary schools, and in the science classes, which are under the control of the science and art department — and which, I may say, in passing, have, in my judgment, done so very much for the diffusion of a knowledge over the country — I think that, in those cases, we may go further, and we may hope to see instruction in the elements of biology carried out, not, perhaps, to the same extent, but still upon somewhat the same principle, as we do here. There is no difficulty, when you have to deal with students of the ages of fifteen or sixteen, in practicing a little dissection and getting a notion, at any rate, of the four or five great modifications of the animal form, and the like is true in regard to plants.

While, lastly, to all those who are studying biological science with a view to their own edification, or with the intention of becoming zoölogists or botanists; to all those who intend to pursue physiology — and especially to those who propose to employ the working years of their lives in the practice of medicine — I say that there is no training so fitted, or which may be of such important service to them, as the thorough discipline in practical biological work which I have sketched out as being pursued in the laboratory hard by.

I may add that, beyond all these different classes of persons who may profit by the study of biology, there is yet one other. I remember, a number of years ago, that a gentleman who was a vehement opponent of Mr. Darwin's views, and had written some terrible articles against them, applied to me to know what was the best way in which he could acquaint himself with the strongest arguments in favor of evolution. I wrote back in all good faith and simplicity, recommending him to go through a course of comparative anatomy and physiology, and then to study development. I am sorry to say he was very much displeased, as

people often are with good advice. Notwithstanding this discouraging result, I venture, as a parting word, to repeat the suggestion, and to say to all the more or less acute lay and clerical paper-philosophers [1] who venture into the regions of biological controversy: Get a little sound, thorough, practical, elementary instruction in biology.

ON THE PEOPLING OF AMERICA.

BY AUG. R. GROTE.[2]

THE conclusion was first reached by myself in a paper [3] read before the American Association, August, 1875 (since reprinted in several journals), that we should find colonies of Arctic man upon mountains in the temperate zone of North America, had all the conditions for his survival on these elevations been fulfilled in his case as they have been in that of certain plants and animals. That the Eskimos are the existing representatives of the man of the American Glacial epoch, just as the White Mountain butterfly (*Oeneis semidea*) is the living representative of a colony of the genus planted on the retiring of the ice from the valley of the White Mountains, seemed to me at that time a natural conclusion. In a subsequent paper,[4] Dr. C. C. Abbott, basing his remarks on paleolithic implements discovered by himself in New Jersey, says: "It is fair to presume that the first human beings that dwelt along the shores of the Delaware were really the same people as the present inhabitants of Arctic America." The title of Dr. Abbott's paper is Traces of an American Autochthon, and in it he institutes a comparison of the paleolithic implements of New Jersey with those of Southern France. According to a foot-note of Dr. Abbott's it appears that in 1875 Dr. Rink [5] was "strongly of opinion that the Eskimo are an

[1] Writers of this stamp are fond of talking about the Baconian method. I beg them, therefore, to lay to heart these two weighty sayings of the herald of Modern Science: —

"Syllogismus ex propositionibus constat, propositiones ex verbis, verba notionum tesseræ sunt. Itaque si notiones ipsæ (*id quod basis rei est*) confusæ sint et temere a rebus abstractæ, nihil in iis quæ superstruuntur est firmitudinis." — Novum Organon ii. 14.

"Huic autem vanitati nonnulli ex modernis summa levitate ita indulserunt, ut in primo capitulo Geneseos et in libro Job et aliis scripturis sacris, philosophiam naturalem fundare conati sint; *inter vivos quærentes mortua.*" — Ibid. 65.

[2] Read before the Buffalo Society of Natural Sciences, February 2, 1877.

[3] Effect of the Glacial Epoch upon the Distribution of Insects in North America, Proc. Am. Assoc. Adv. Sci., Detroit Meeting, B. Natural History, 225.

[4] Am. Nat., June, 1876, 329.

[5] Tales and Traditions of the Eskimo, London, 1875.